Intelligent Door Lock

an advanced access control system

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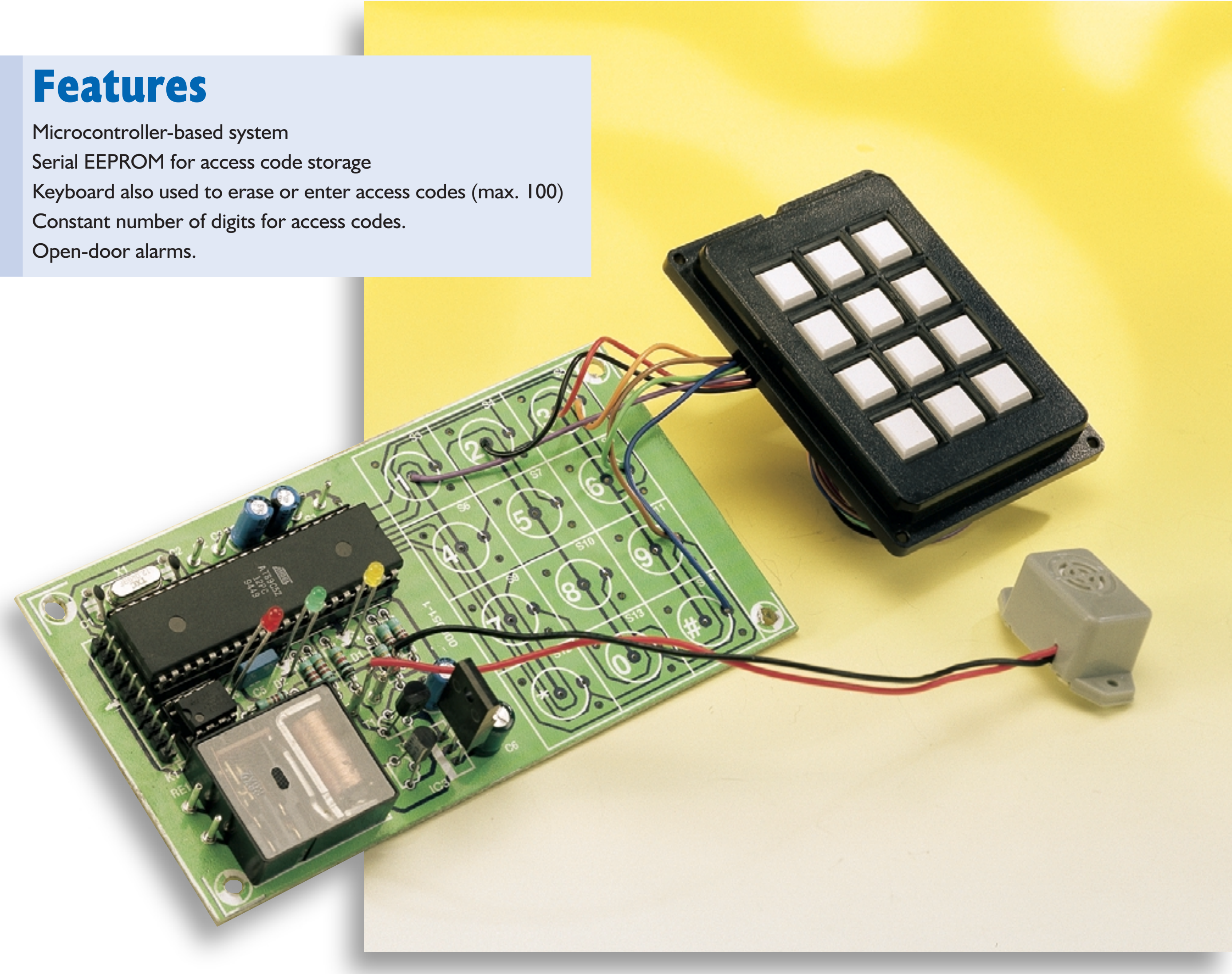
The Intelligent Door Lock employs an entrance code to control access to certain rooms or buildings. The heart of the system is a microcontroller manufactured by Atmel. The system employs an electric door latch and has visual and acoustic indicators for ease of use and your personal safety. Access codes are stored in a non-volatile memory device.

Features

Microcontroller-based system
Serial EEPROM for access code storage
Keyboard also used to erase or enter access codes (max. 100)
Constant number of digits for access codes.
Open-door alarms.



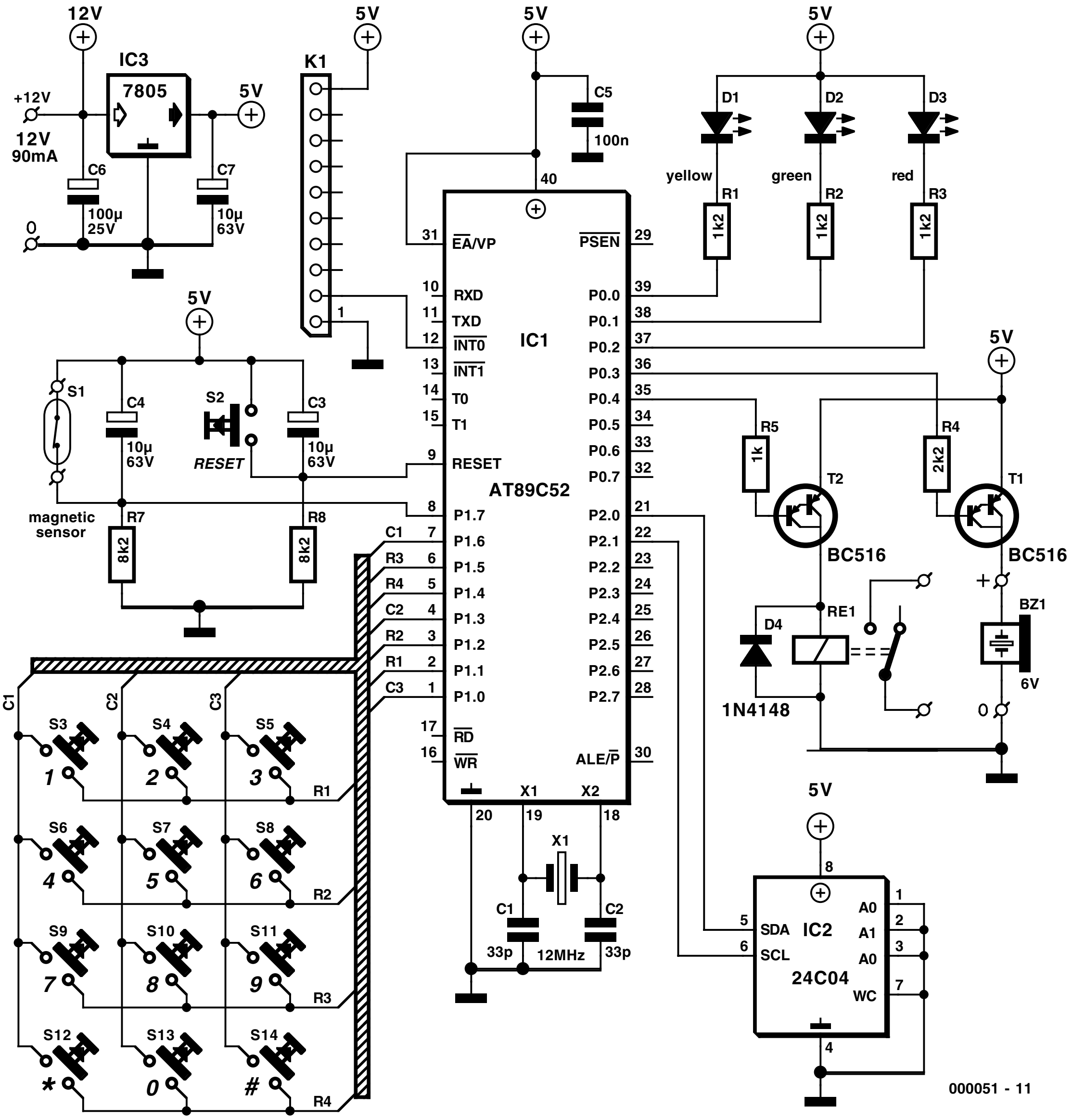


Figure 1. Circuit diagram of the Code Lock.

The flexibility of the system is due to a microcontroller running a program written specifically for the purpose of controlling access to rooms, apartments, hallways and complete buildings.. An all-hardware version of such a system would be much complex and costly. The use of an EEPROM allows access codes to be stored without having to worry about loss of data due to power supply failures.

The access codes can easily be reprogrammed by switching the system into 'supervisor mode', as will be discussed further on.

A magnetic sensor (reed switch) is included to detect if the door is closed or open. The system enters a steady state until the door is closed, and this situation is indicated by a green light. If the door is kept open for a specified time, a buzzer will sound until the door is finally closed.

This alarm can be turned off by connecting the leads of the magnetic sensor on the door.

Basic elements

The different blocks that constitute the system are

1. keyboard and indicators
2. main circuit
3. solenoid-driven door latch
4. magnetic detector (reed switch)

Items 1 and 2 are found back in the circuit diagram shown in **Figure 1**. Microcontroller IC1, a Type AT89C52 from Atmel is the 'decision maker' in this circuit, handling such tasks as scanning the keypad (S3-S14), and reading the status of magnetic sensor S1 (a reed switch) and reset switch S2. It also controls a number of output devices including three status indicator LEDs (D1, D2 and D3), a relay (solenoid) driver (T2), and a buzzer driver (T1) for acoustic signals. System data including the code to open the door are stored in an EEPROM, IC2, which is linked to the microcontroller by two port lines, P2.0 (serial data) and P2.1 (serial clock).

The microcontroller runs at a speed of 12 MHz which is determined by quartz crystal X1 and capacitors C1 and C2.

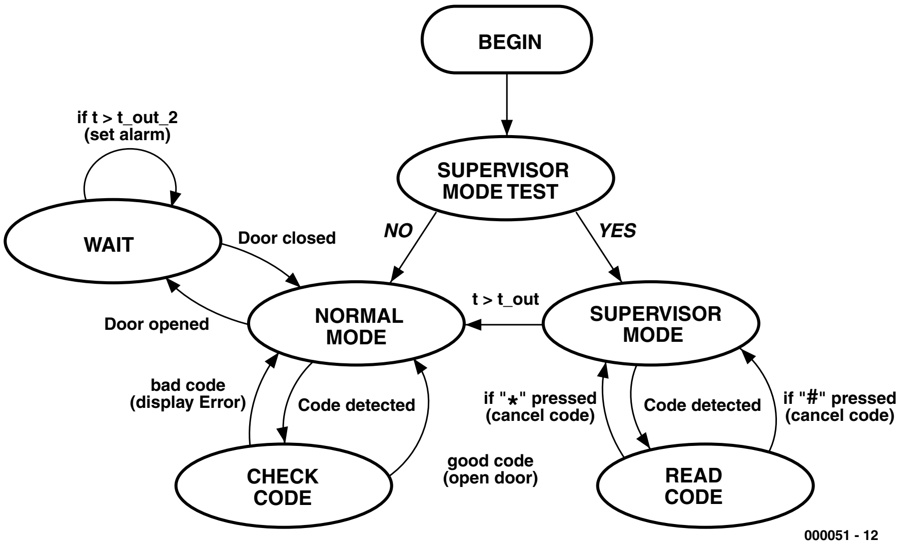


Figure 2. Flow chart of the software running inside the AT89C52 microcontroller.

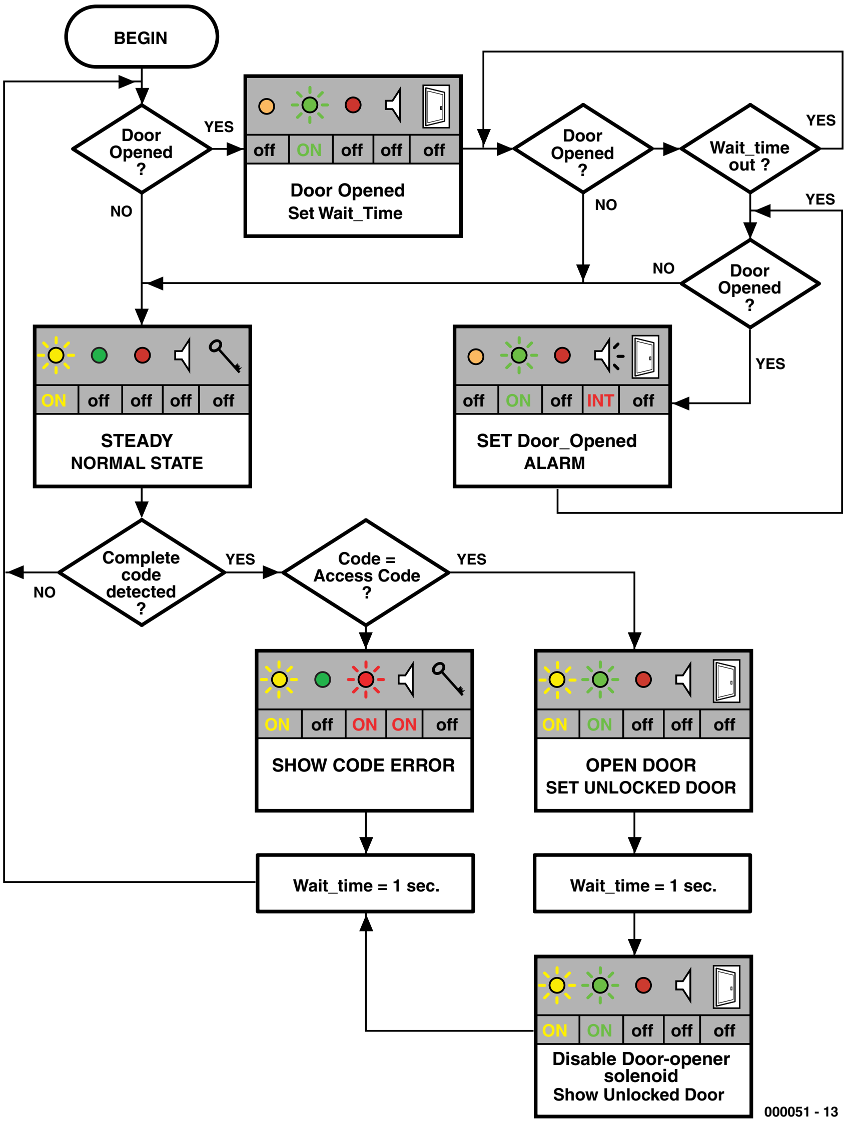


Figure 3. Flowchart and indicator activity during Normal Mode.

The power-on reset circuit is conventional, consisting of electrolytic capacitor C3 and resistor R8. When power is applied to the circuit, the microcontroller's reset input will be held high by C3 until the capacitor is sufficiently charged. The delay introduced in this way ensures that the microcontroller is not enabled (i.e., released from its reset state) until the supply voltage is stable. Pressing S2 allows the circuit to be reset manually.

The circuit has an on-board voltage stabilizer, IC3, which provides a clean 5-V rail for the other parts to work on. Just about any small mains adaptor rated at 9-12V d.c and 150 mA or so should be suitable to power the code lock. Most of the current will, of course, go into actuating the on-board relay, Re1. The electric door latch will typically require its own power supply. Usually this will be 12 V or 24 V, but mains-powered types may also be used if electrical safety precautions are observed and the coil current does not exceed the contact specification of the on-board relay. For safety's sake, however, we'd suggest going for a low-voltage dc-operated door latch.

Software in charge

In this circuit, a microcontroller is used instead of a handful of digital ICs and other hardware to keep the component count low while maximizing the number of ways in which the design can be matched to real-life requirements. In other words, during the design stages, certain new features are far easier to implement by adapting the software than by, say, adding half a dozen components (and changing the board layout, etc.)

A flowchart illustrating the operation of the software packed in the Atmel microcontroller (in the form of an executable program) is shown in **Figure 2**. Some of the labels and descriptions given in this diagram will be discussed below as part of the Mode descriptions.

The system operation consists of two modes, 'normal' and 'supervisor'. **Supervisor mode** is used to update the entrance codes. The only way to enter this mode is by keeping the *, 5 and # keys pressed when starting-up the system. In all other cases, the system enters normal mode. The system will remain in the latter mode unless the triple key combination *5# is detected. The main function of the normal mode is to switch on the solenoid-driven latch unlocking the door (only when the access code is activated) or to inform non-authorized visitors that the code is incorrect. When the door

COMPONENTS LIST

Resistors:
R1,R2,R3 = 1kΩ2
R4 = 2kΩ2
R5 = 1kΩ
R7,R8 = 8kΩ2

Capacitors:
C1,C2 = 33pF
C3,C4,C7 = 10µF 63V radial
C5 = 100nF
C6 = 100µF 25V radial

Semiconductors:
D1 = LED yellow, high efficiency
D2 = LED, green, high efficiency
D3 = LED, red, high efficiency
D4 = 1N4148
T1,T2 = BC516
IC1 = AT89C52-12PC, programmed, order code **000051-41**
IC2 = 24C04
IC3 = 7805

Miscellaneous:
K1 = 10-way SIL header
S1 = Reed switch and permanent magnet for door mounting
S2 = pushbutton, 1 make contact
S3-S14 = pushbutton, 1 make contact, Marquardt type 6425
Basic switch: Conrad Electronics order #70 68 92
Keycaps: Conrad Electronics
# 70 69 06 #70 69 14
#70 69 22 #70 69 30
#70 69 49 #70 69 57
#70 69 65 #70 69 73
#70 69 81 #70 69 90
#70 70 07 #70 70 15
X1 = quartz crystal 12MHz
Bz1 = buzzer, passive type, 6V operating voltage
RE1 = relay, horizontal mounting, 1 changeover contact, coil voltage 6V or 5V, e.g., Siemens V23057-A0001-A101
PCB, order code **000051-1**
Disk (AT89C52 source code), order code **000051-11**.

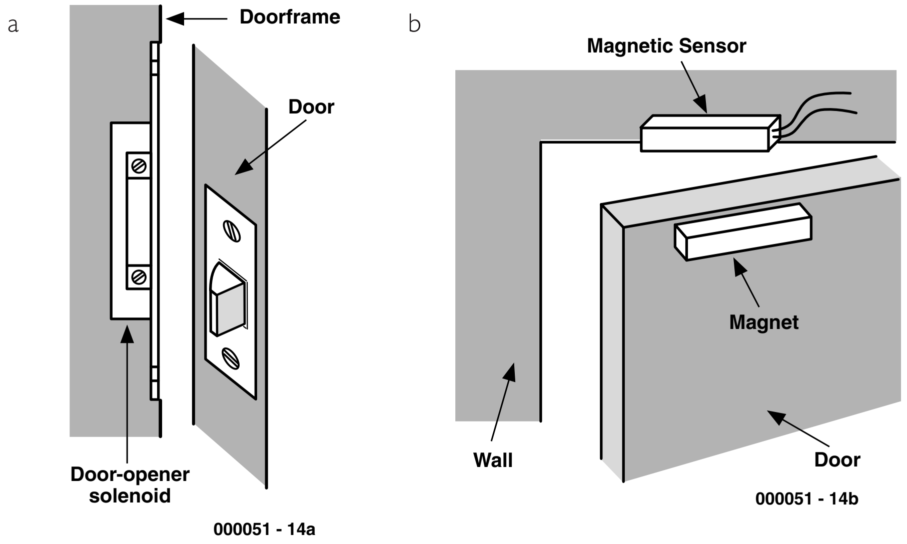


Figure 4. Suggested method of mounting the door opener solenoid and the magnet/reed switch combination.

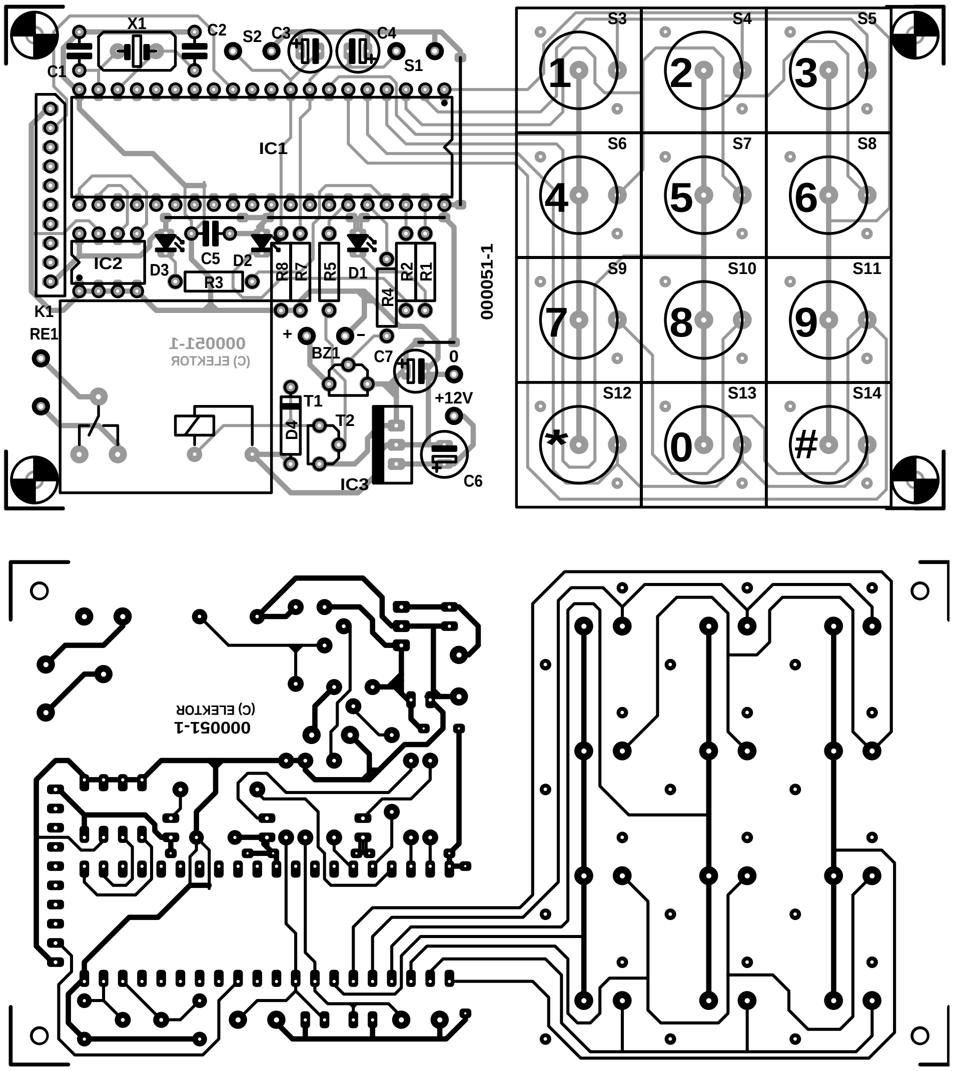


Figure 5. Printed circuit board layout. Board available ready-made through our Readers Services.

is unlocked and the latch is on there will be a brief time interval to allow the authorized user to enter.

Normal Operation Mode

This is the usual operation mode. The software flow diagram in **Figure 3** also shows the status of the various indicators and output devices when the microcontroller branches to certain routines depending on external conditions.

The main functions connected with the opening of the door are performed during normal-mode operation. The door-opener solenoid will be switched on only if the access code is correctly typed on the keypad. The 'door-open' alarm will also be activated when necessary.

The system will always operate in this mode unless it is rebooted to enter the supervisor mode.

The system will continue to be clocked while the door is open and a green LED indicator will show this state while the 'open-door' alarm is still on but the built-in delay is over.

Supervisor Mode

Only this mode allows the system codes to be changed. The only way to enter this mode is to hold the *, 5 and # keys down while starting-up the system. The system will confirm the positive result of the supervisor test by a beep from the buzzer and by flashing the three light indicators in the same rhythm. In addition, a time interval is created for the release of the *, 5 and # keys without considering any one of these as the first digit of a possible entrance code. It is also important to make sure that the door is closed before starting the password modification process. A period of 30 seconds is allowed to change the entrance code. If supervisor mode is successfully entered but no further action is detected, the system will enter normal mode after some time. This delay is reset after each entrance code modification.

The operations needed to activate or erase the different access entrance codes are the following. Firstly the supervisor mode has to be entered. Then, the password you want to add or erase is typed on the keypad. Finally you should push # to add the password, or * to delete it.

Reset

The system can be reset by pushing a key installed in the circuit. As a matter of course, this switch is not easily accessible. The password validated before the system is reset will be kept in memory.

Installation

A suggested installation of the door-opener solenoid and the magnetic sensor is shown in **Figure 4**. The ideal place to mount the magnetic (reed) contact is on the top part of the door frame (**Figure 4a**). The fixed magnet that belongs with the reed switch then becomes the 'mobile' part by attaching it to the top edge of the door as shown in **Figure 4b**. Door magnets and reed switches are usually sold by the pair.

Construction

The layout of the PCB designed for the project is shown in **Figure 5**. The sections reserved for the actual control circuit (left) and the keypad (right) are easily distinguished. Do not cut the board between these sections however, as you will break the seven interconnection tracks and no connector system has been provided as an alternative. As you can see from the introductory photograph, it is possible to use an existing keypad and wire it to the relevant solder pads on the keyboard section of the PCB.

There are no special precautions to observe when populating this board. Make sure, however, you know the required length of the LED terminals before soldering these devices in place. The aim is, of course, to ensure that the tops of three LEDs are level with the keytops so they can all protrude a bit from the top panel of the case. For the Atmel microcontroller we strongly suggest using an IC socket.

Provided the unstabilized input voltage from your mains adaptor does not exceed 12 V, voltage regulator IC3 should not require a heatsink.

Electrical installation

The connections to and from the main board have to be made such that the relevant wires can not be easily manipulated. Along the same train of thought, the controller/keyboard circuit has to be built in a tamper-proof enclosure. If you can not obtain the specified pushbuttons and caps, an alternative is to wire up an existing keypad and (if necessary) change the keycap symbols. We leave it to you to find ingenious ways of realizing these requirements! After all, you want to protect what's yours, don't you?

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DIY chip programming

You are lucky if you have a programmer for the AT89C52 micro, plus a suitable assembler. The assembly-code file (microcontroller program code) for the AT89 microcontroller used in this project is available either on disk (order code **000051-11**) or as a **free download** from the Subscribers Only section of our website http://www.elektor-electronics.co.uk.